

Claims

1. Method for adapting an injection valve characteristic, said characteristic representing a reference injection behavior, of
5 a triggered fuel injection valve of an internal combustion engine to aging-related changes or manufacturing-related variations of an actual injection behavior, wherein
 - a) during an operating state of the internal combustion engine, which operating state does not require a fuel
10 injection, the injection valve is triggered intermittently in accordance with a trigger duration, while otherwise no fuel injection occurs, such that at least one work cycle with triggering follows or precedes at least one work cycle without triggering of the injection valve,
 - 15 b) a rotational-speed value or a value of a rotational-speed-dependent variable of the internal combustion engine is detected in each case for the work cycle with triggering and for at least one of the work cycles without triggering and
 - c) a difference between the detected values is established and
20 a correction of the injection characteristic is effected thereupon.
2. Method according to claim 1, in which a difference between the detected values is established and derivatives of a first
25 and/or higher order are calculated therefrom.
3. Method according to claim 2, in which differences are calculated on the basis of measured segment times, difference quotients are calculated from said differences, and
30 derivatives of a first and higher order are derived therefrom.
4. Method according to one of the preceding claims, in which

an overall profile of the rotational-speed value or of the rotational-speed-dependent value is analyzed using signal-analysis methods over a plurality of work cycles with and without triggering, and interference effects are identified and eliminated.

5 5. Method according to one of the preceding claims, in which the trigger duration is increased step-by-step.

10 6. Method according to one of the preceding claims, in which in step c) an angular momentum value is calculated for a angular momentum which was produced by the triggering of the injection valve with the trigger duration.

15 7. Method according to claim 6, in which the angular momentum value is calculated in accordance with the following formula:

$$D = (\pi/F1) \cdot M \cdot (dN+ - dN-) + dJ,$$

20 where F1 is a factor that is dependent on a number of cylinders, D is the angular momentum value, M is a moment of inertia of the internal combustion engine, dN+ is a rotational-speed gradient of the work cycle with triggering of the injection valve, dN- is a rotational-speed gradient of one
25 of the work cycles without triggering of the injection valve, and dJ is a factor for a braking moment which is caused by internal friction of the internal combustion engine.

30 8. Method according to one of the preceding claims, wherein the steps a) and b) are executed several times with an unchanged trigger duration for the purpose of noise suppression.

9. Method according to claim 6 concerning an internal combustion engine which is designed as a multi-cylinder internal combustion engine, in which a segment wheel that is driven by the internal combustion engine is sampled and a first work cycle without triggering of the injection valve of a specific cylinder, then a second work cycle with triggering of the injection valve of the specific cylinder, and then a third work cycle without triggering of the injection valve of a specific cylinder are executed, wherein a segment time is specified in at least the first, second and third work cycle for the specific cylinder, said segment time lasting for the passage of a segment of the segment wheel during the working stroke of the cylinder, and wherein the angular momentum is calculated in accordance with the following equation:

$$D = F2 \cdot \pi \cdot M ((Tx3 - Tx2)/(ST-)^3) - (Tx2 - Tx1)/(ST+)^3) + dJ,$$

where F2 is a factor that is dependent on the number of cylinders, D is the angular momentum value, M is a moment of inertia of the internal combustion engine, dJ is a factor for a braking moment which is caused by internal friction of the internal combustion engine, Tx1 is the segment time for the specific cylinder in the first work cycle, Tx2 is the segment time for the specific cylinder in the second work cycle, Tx3 is the segment time for the cylinder in the third work cycle, ST- is the average total duration of the passage of all segments during a work cycle without triggering of the injection valve and ST+ is the average total duration of the passage of all segments during one of the work cycles with triggering of the injection valve.

10. Method according to claim 7 or 9, in which a difference between two values is established for the purpose of determining the factor for the braking moment which is caused by the internal friction of the internal combustion engine, wherein one value is assigned to one of the work cycles of the internal combustion engine without triggering of the injection valve and the other is assigned to the work cycle of the internal combustion engine with triggering of the work cycle.
- 10 11. Method according to claim 6, in which a fuel-mass value for a fuel mass that is delivered by the injection valve is derived from the angular momentum value, the fuel-mass value is assigned to the trigger duration and then used for correcting the injection valve characteristic.